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SPECIFICATION FOR OPTICAL GLASS

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NEW DELHI 110002

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Indian Standard
SPECIFICATION FOR OPTICAL GLASS

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Indian Standard
SPECIFICATION FOR OPTICAL GLASS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 9 September 1960, after the draft finalized by the Optical and Mathematical Instruments Sectional Committee had been approved by the Engineering Division Council.

0.2 Optical glass differs from ordinary glass with respect to the extreme care and precise control exercised during its manufacture, so as to ensure perfect homogeneity, freedom from colour (except where certain oxides and elements are deliberately introduced for the manufacture of coloured glass) and faithful reproduction of the physical properties from batch to batch. As it forms the basic material from which all types of optical components for precision instruments are manufactured, the necessity to lay down a standard to guide the quality of optical glass produced for different purposes is of considerable importance both for the manufacturer and the purchaser of optical glass.

0.3 This standard describes the commonly recognized types and grades of optical glass, their physical properties, the defects commonly found in the material, and the methods of acceptance tests for the material. This standard does not, however, cover special glasses required to be used as filters, and other coloured glasses.

0.3.1 The durability grading (*see* **4.10**) on the basis of the results of accelerated test is qualitative and it can only be taken to indicate the probable behaviour of glass surfaces under conditions of natural exposure. In order to evaluate the grading, it is necessary to assess the durability against standard types of glass tested under identical conditions.

0.4 This specification requires reference to the following Indian Standards:

IS : 1286-1958 PICTORIAL MARKINGS FOR HANDLING INSTRUCTIONS FOR NON-DANGEROUS GOODS
IS : 1399-1959 GLOSSARY OF TERMS USED IN OPTICAL TECHNOLOGY

0.4.1 Wherever a reference to any Indian Standard mentioned in **0.4** or otherwise appears in this specification, it shall be taken as a reference to the latest version of the standard.

0.5 This standard is one of a series of Indian Standards for optical instruments and is a necessary adjunct to the individual specifications for the different types of optical instruments. Other standards published so far in the series are:

IS : 988-1959 GENERAL REQUIREMENTS FOR OPTICAL COMPONENTS
IS : 1399-1959 GLOSSARY OF TERMS USED IN OPTICAL TECHNOLOGY

0.6 Metric system has been adopted in India and all quantities and dimensions in this standard have been given in this system.

0.7 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS: 2-1960 Rules for Rounding Off Numerical Values (*Revised*). The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

0.8 This standard is intended chiefly to cover the technical provisions relating to optical glass, and it does not include all the necessary provisions of a contract.

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1. SCOPE

1.1 This standard deals with the physical characteristics and properties of optical glass, the defects and faults often come across in the material, the methods of test employed for their location, grading of optical glass according to the degree of permissibility of these common defects for different types of work, and the methods of marking and packing of the material.

2. TERMINOLOGY

2.0 For the purpose of this specification, the definitions given in IS: 1399-1959 and the following definitions shall apply.

2.1 **Abbe Number** V — A constant for a given sample of glass and also referred to as 'reciprocal dispersion' or constringence of optical glass. Abbe Number V is given by the expression ·

$$V = \frac{n_d - 1}{n_F - n_C}$$

where n_d is the refractive index of the glass for the d line of helium, and n_F and n_C those for the F and C lines of hydrogen.

2.2 Felps — Cracks extending through the material in a moulded blank

2.3 Immersion Refractometry — A branch of optics where the refractive index of any transparent solid of odd shape is measured by matching it with that of a mixture of liquids suitably chosen; the liquids may be, for example, carbon disulphide, benzene, glycerine, mono-bromonaphthalene, water, etc.

2.4 Moulded Blanks — Pieces of optical glass moulded to predetermined sizes and shapes approximating to those of the finished component to reduce wastage of glass and to keep machining operations to the minimum.

2.5 Partial Dispersion — Between any two sets, wave-lengths of visible radiation is the difference between the refractive indices of the material for the two wave-lengths (*see* **4.9.2**)

2.6 Slabs -- Optical glass obtained by cutting or forming the chunk glass into plates and slabs.

2.7 Spectral Lines — The nine spectral lines used to define the optical properties of each glass type in terms of refractive index and dispersion values are indicated in the following table, the wave-length figures being in Ångström units:

	POTASSIUM (MEAN OF DOUBLE LINE)	HYDROGEN	SODIUM (MEAN OF DOUBLE LINE)	HELIUM	MERCURY
Red	A' 7682	C 6563			
Yellow			D 5893	d 5876	
Green					e 5461
Blue		F 4861 G' 4340			g 4358
Violet					h 4047

2.8 Type Number — A reference number of six digits used to indicate the glass type, the first three digits composed of the numerals following the decimal point in the mean value of the refractive index of the material for helium *d* line (n_d) and the second three indicating the Abbe Number without reference to the decimal point (*see* **6.1**).

3. TYPES

3.1 While optical glasses are broadly classified as Crown and Flint, there are well recognized further subdivisions under each category, some of which are indicated under **3.1.1** and **3.1.2** showing their abbreviated forms within brackets.

3.1.1 *Crown* — Fluor Crown (FC), Boro-Silicate Crown (BSC), Light Barium Crown (LBC), Medium Barium Crown (MBC), Dense Barium Crown (DBC) and Soft Crown (SC).

3.1.2 *Flint* — Telescope Flint (TF), Barium Light Flint (BLF), Barium Flint (BF), Light Flint (LF), Dense Flint (DF), Extra-Dense Flint (EDF), and Double Extra-Dense Flint (DEDF).

NOTE — The optical constants of the above types of glasses as well as their ability to resist atmospheric attack differ, thereby facilitating a wide choice to the optical designer (*see* 4 and 5). In addition, there are new rare earth optical glasses, which are used for special purposes.

4. GENERAL REQUIREMENTS

4.0 Optical glass of all types, whether supplied in the form of blocks, slabs or moulded blanks, shall conform to the following general requirements.

4.1 Homogeneity — Optical glass shall be free from any inhomogeneity in composition or optical properties.

4.1.1 Between different portions of the same piece of glass, the measured values for refractive index and dispersion shall exhibit no variations beyond the limits of accuracy as specified in **4.9.1** and **4.9.2** respectively.

4.2 Stones and Crystallization Bodies — Optical glass shall be totally free from fragments of undissolved material or impurities and crystallized deposits of any of the constituents. Their presence may be detected by visual inspection through two parallel polished faces of a block or by the methods specified in Appendix A.

4.3 Colour

4.3.1 Optical glass, other than Dense Flint, Extra-Dense Flint and Dense Barium Crown glasses, shall be free from colour to the extent that when a white object is viewed through two opposite polished faces of a plate of the material, of two centimetres thickness, the object shall appear unchanged in colour.

4.3.2 Under the same conditions as in **4.3.1**, a slight yellow colour is permissible in the case of Dense Flint and Extra-Dense Flint glasses and a slight green colour in the case of Dense Barium Crown glass.

4.4 Transparency — Optical glass shall be totally free from cloudiness or milky appearance which sometimes arises during manufacture.

4.5 Light Absorption

4.5.1 When tested for transmissivity of white light using a standard photometer, optical glass other than Dense Flint, Extra-Dense Flint and Dense Barium Crown glasses shall indicate absorption of not more than one percent of the incident light per centimetre of the light path.

4.5.2. Dense Flint, Extra-Dense Flint and Dense Barium Crown glasses shall absorb not more than two percent of the incident light per centimetre of the light path under the same conditions as **4.5.1**.

4.6 Striae, Ream and Cords — Optical glass shall be examined for striae by the methods specified in Appendix A, and graded according to the striae content as follows:

Grade *A*	Containing no visible striae or cords.
Grade *B*	Containing scattered striae, which are just visible when viewed in the direction of maximum visibility.
Grade *C*	Containing light striae, which are sensibly parallel to the face of the blocks, slabs and blanks.

4.7 Bubbles and Seeds — Optical glass in the form of slabs or blanks, from which components may be processed and graded according to the bubble and seed content as follows:

Grade *a*	Totally free from bubbles of size larger than 0·01 millimetre in mean diameter.
Grade *b*	Containing on the average not more than one bubble per 16 cubic centimetres of glass, the size of any individual bubble not exceeding 0·08 millimetre in diameter.
Grade *c*	Containing on the average not more than one bubble per cubic centimetre of glass, provided that the total projected area of all bubbles and seeds on a polished surface shall not exceed 0·1 percent of the surface area per 10 centimetres of the light path, the size of any individual bubble not exceeding 0·20 millimetre.

NOTE — For Dense Barium Crown and other Barium glasses, allowances for bubbles shall be twice those mentioned for grade *c* or as specified in the contract.

AMENDMENT NO. 1 DECEMBER 1982
TO
IS:1400-1960 SPECIFICATION FOR OPTICAL GLASS

Alteration

(*Page 7, clauses 4.8.1 and 4.8.2*) - Substitute the following for the existing clauses:

'4.8.1 Optical glass shall be well annealed such that the residual strain is minimum and symmetrically distributed. The birefringence of the glass shall be such as to cause a relative retardation, between the two beams formed on it, of not more than the following limits depending upon the end use of the optical glass:

a) 2 nm path difference per centimetre length of light path	For critical and highly sensitive optical elements used in polarizers, interference instruments, precision cameras, high power microscope objectives,etc
b) 5 nm path difference per centimetre length of light path	For telescope objectives, eye-pieces, projector lense, prisms,etc
c) 10 nm path difference per centimetre length of light path	For condenser lenses, magnifiers, correcting systems, viewfinder lenses,etc

4.8.2 The method for determination of strain shall be as described in 6.2 of IS:4382-1967 Specification for Non-tinted Opthalmic Glass.'

(EDC 36)

Reprography Unit, ISI, New Delhi, India

4.8 Strain

4.8.1 Optical glass shall be well annealed, such that the residual strain is minimum and is symmetrically distributed. The birefringence of the glass shall be such as to cause a relative retardation, between the two beams formed on it, of not more than 10 millimicrons per centimetre of the light path for sodium light when tested with a Babinet Compensator.

4.8.2 An alternative qualitative method of test is as follows:

> The specimen of glass, polished on two parallel faces shall be held in the path of light between 'Crossed Nicols' in a sensitive polariscope and rotated in its own plane. The amount of strain present in the examined part of the specimen will be revealed by the colour of the transmitted light. When the test piece shows no colouration beyond a light grey, the glass is suitable for optical work. Any evidence of colour or a bright field indicates bad annealing.

4.9 Refractive Index and Partial Dispersion

4.9.1 The refractive index for the *d* spectrum line of each lot of glass, measured with a standard refractometer and corrected to 20°C, shall be furnished by the manufacturer to the fourth decimal place and shall be correct within plus or minus 0·000 1. The refractive index for the hydrogen *G* line shall be similarly measured and furnished by the manufacturer.

4.9.2 The partial dispersion for the spectral intervals between the spectrum lines *A* and *C*, *C* and *d*, *d* and *F*, *d* and *e*, *F* and *g*, and *g* and *h* shall be furnished by the manufacturer to the fifth decimal place and shall be correct within plus or minus 0·000 03.

4.9.3 The Abbe number (*V*-value) of each lot of glass shall be furnished by the manufacturer to the first decimal place.

4.9.4 The melt to melt variation of the refractive index for the *d* spectrum line and of the Abbe number of any type of glass shall be within the tolerances indicated in Table I.

4.10 Durability

4.10.1 Samples from each batch of optical glass shall be tested for the resistance of newly polished surfaces or surface of freshly broken chunks of the material to atmospheric attack by the thermodyne test and graded for durability as follows:

GRADE	RESISTANCE AS DETERMINED BY ACCELERATED TESTS	PROBABLE BEHAVIOUR
D1	Excellent	Likely to remain free from attack
D2	Good	Dull patches likely to appear after a long period (4 to 5 years)
D3	Fair	Tarnish spots indicating interference films likely to appear within 2 to 3 years
D4	Poor	Tarnish spots likely in shorter periods

NOTE — As the grading is the result of accelerated tests and is qualitative, it can only be taken to indicate the probable behaviour of glass surfaces under conditions of natural exposure (*see* **0.3.1**).

TABLE I TOLERANCES ON REFRACTIVE INDEX AND ABBE NUMBER FOR DIFFERENT TYPES OF OPTICAL GLASSES

(*Clause* 4.9.4)

TYPE	TOLERANCE	
	n_d ±	V ±
Fluor Crown	0·001 0	0·5
Boro-Silicate Crown	0·001 0	0·5
Light Barium Crown	0·001 0	0·5
Medium Barium Crown	0·001 5	0·5
Dense Barium Crown	0·001 5	0·4
Soft Crown	0·001 0	0·5
Telescope Flint	0·001 0	0·4
Barium Light Flint	0·001 5	0·4
Barium Flint	0·001 5	0·3
Light Flint	0·001 5	0·3
Dense Flint	0·001 5	0·3
Extra-Dense Flint	0·001 5	0·3
Double Extra-Dense Flint	0·001 5	0·3

4.10.2 *Thermodyne Test* — Freshly broken or polished pieces of optical glass shall be placed in a closed vessel containing water, with one non-polished surface resting on supports above the water. The vessel shall be kept in a chamber provided with thermostatic control and subjected to temperature cycles from room temperature to 60°C, each cycle being of two hours duration, for a period of 12 days. At the end of the period, the exposed surface shall be examined and the degree of attack assessed and recorded by comparison with standard types of glass tested simultaneously.

5. SPECIAL REQUIREMENTS

5.1 Moulded Blanks

5.1.1 Glass formed in blanks shall, in addition to satisfying the general requirements in **4**, be free from felps and from folds introduced during the moulding operation. The blanks shall, in addition, be free from edge or surface cracks resulting from contact with the tool during moulding.

5.1.2 The grade of glass used in moulding of blanks shall be clearly stated in the contract (*see* **3.1**, **4.6**, **4.7** *and* **4.10**).

5.1.3 The dimensions of moulded blanks shall conform to the specifications of the contract or relevant drawings. Where only the dimensions of the finished components are specified, sufficient additional material shall be provided to allow for subsequent grinding operations. Such additional material, except when otherwise stated in the contract, shall be as indicated in Table II, the edge thickness of the moulded blank being not less than 3 mm.

6. MARKING

6.1 All blocks and slabs forming part of a lot, from the same melt and annealing, shall have the glass type, refractive index for helium *d* line (n_d) with the Abbe number, melt number and the striae and bubble gradation (where applicable) marked on them in waterproof, abrasion resistant marking ink (*see* **2.8**).

Example:

A Medium Barium Crown Glass (MBC) of refractive index 1·569 30 for helium *d* line (n_d) with an Abbe number 55·8 of melt 5725 with striae and bubble gradation *A* and *a*, shall have the following marking:

MBC 569/558 5725 *Aa*

TABLE II ADDITIONAL MATERIAL REQUIRED IN MOULDED BLANKS WHEN ONLY DIMENSIONS OF FINISHED COMPONENTS ARE SPECIFIED

(*Clause* 5.1.3)

Finished Component	Shorter Radius	Diameter	Minimum Extra Material* for Edging on Diameters	Minimum Extra Material* for Grinding on Each Surface
(1)	(2)	(3)	(4)	(5)
	mm	mm	mm	mm
Lenses	Under 100	Under 75	3	1·5
		75-125	4	1·5
	Over 100	—	7	1·5
Graticules and windows	—	Under 75	3	1·5
	—	Over 75	4	1·5
Prisms (all dimensions under 100 mm)			—	3·5

*The figures given in col 4 and 5 should be normally not exceeded by 33⅓ percent.

6.2 Moulded blanks shall be marked in a similar manner, except that the melt number shall be replaced by the purchaser's part number and shall not include the grading.

Example:

A Medium Barium Crown Glass (MBC) of refractive index 1·569 30 for helium *d* line (n_d) with an Abbe number 55·8 for part No. 26 shall have the following marking:

MBC 569/558 26

6.2.1 As far as practicable, spherical surfaces shall be kept free of raised marking to permit use of gauges.

6.3 The blocks, slabs and blanks of optical glass may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act, and the Rules and Regulations made thereunder. Presence of this mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard, under a well-defined system of inspection, testing and quality control during production. This system, which is devised and supervised by ISI and operated by the producer, has the further safeguard that the products as actually marketed are continuously checked by ISI for conformity to the standard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

7. PACKAGING

7.1 Unless otherwise specified, not more than 5 kg of any one type of blocks, slabs or blanks of optical glass, with slip sheets of soft paper between them, shall be wrapped in kraft paper to form a unit package, the joints being secured with adhesive tape. Each type and size of slab and blank shall be kept separate when packed.

7.1.1 On each such package shall be marked the material, type, size, quantity and the name of the manufacturer.

7.2 Not more than ten such unit packages, securely cushioned separately with suitable material, shall be packed in a plywood or other suitable wooden box, in accordance with normal commercial practice.

7.2.1 Information regarding the material, type, size and quantity of optical glass and the name of the manufacturer shall be marked on the box together with appropriate marking as for all fragile material intended for transit (*see* IS: 1286-1958).

APPENDIX A

(*Clauses* 4.2 *and* 4.6)

INSPECTION FOR STRIAE, BUBBLES, SEEDS AND STONES

A-1. TESTS

A-1.0 Every block, slab and blank of optical glass shall be tested for defects by one of the following methods.

A-1.1 Two opposite parallel faces of the slab under test shall be polished to facilitate examination. Light from a small and bright source is collimated by a condensing lens and a ground glass plate placed normal to the collimated beam, several metres from the lens, as in Fig. 1A. The test piece of glass may be placed between the lens and plate such that the light is incident on one of the polished faces, causing its shadow to fall on the ground glass plate. Even minute striae, bubbles or other embedded impurities in the glass will appear black and sharply defined in the shadow.

By placing the test piece in two different positions, defects in the body of he test piece may be located by this method.

A-1.2 When polishing of test pieces is not practicable (as for formed blanks), it is necessary to use an optical cell filled with an immersion liquid of the same refractive index as of the glass to be inspected. A small source of monochromatic light is placed at the focus of a collimating lens L_1 and a movable cross slit at the focus of another lens L_2, as shown in Fig. 1B. The piece of glass to be inspected is immersed in the liquid and the cell placed in the collimated beam between the lenses. The defects are observed by moving or tilting the glass.

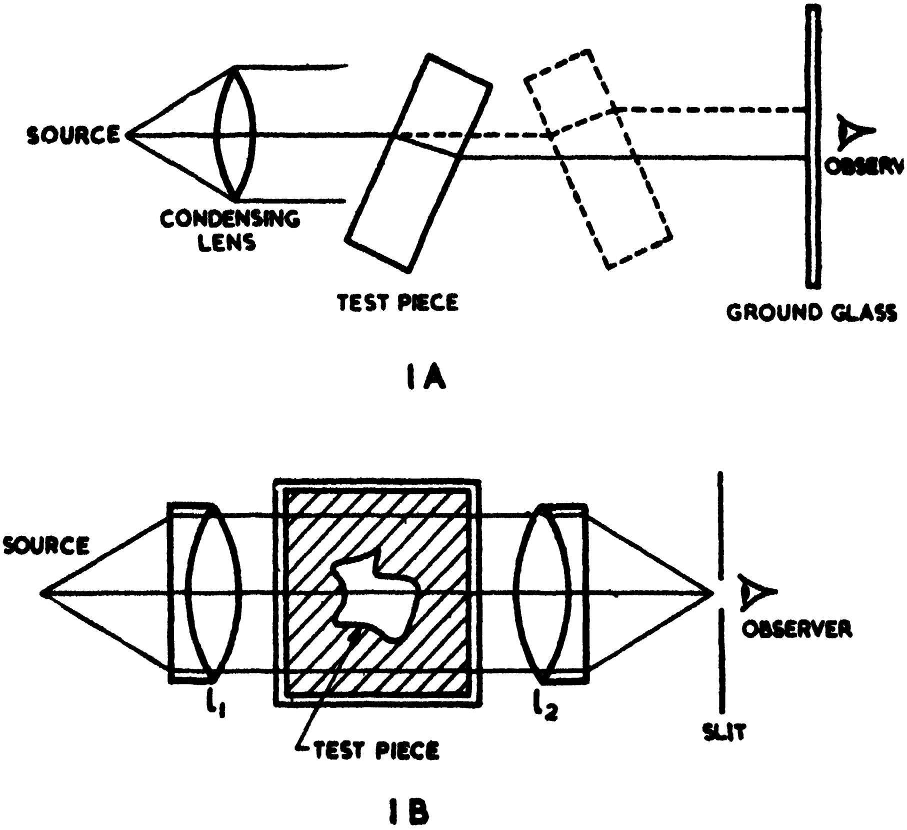

Fig. 1 Arrangements for Testing of Glass Slabs for Striae, Bubbles, Seeds and Stones

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